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ABSTRACT

This study evaluated the achievement effects of the Team-Assisted Individualization (TAI) mathematics program over a 24-week period. Involved were 1,317 students in grades 3, 4, and 5, with 700 students in 31 classes receiving TAI instruction and a control group of 617 students in 30 classes receiving other mathematics instruction on the same objectives. Analysis of covariance was used to analyze the data, with achievement measured by the Mathematics Concepts and Applications and the Mathematics Computation subtests of the Comprehensive Test of Basic Skills. TAI classes gained more than control classes on each test at each grade level. The differences were statistically significant for grades 3 and 5 on the Computation subtest. On the Concepts and Applications subtest, differences were statistically significant for grade 4 and marginally significant for grade 5. In overall analyses, the TAI classes significantly exceeded control classes on both tests. (Author/MNS)

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COMBINING STUDENT TEAMS AND INDIVIDUALIZED INSTRUCTION IN MATHEMATICS: AN EXTENDED EVALUATION

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The Johns Hopkins University

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The Center also supports a Fellowships in Education Research program that provides opportunities for talented young researchers to conduct and publish significant research and encourages the participation of women and minorities in research on education.

This report, prepared by the School Organization Program, describes a 24-week evaluation of the Team-Assisted Individualization (TAI) math program in grades three, four, and five.

Abstract

This study evaluated the achievement effects of the Team-Assisted Individualization (TAI) math program over a 24-week period. The subjects were 1317 students in grades three, four, and five, with 700 students in 31 classes receiving TAI instruction and a control group of 617 students in 30 classes receiving other math instruction on the same objectives.

Analysis of covariance was used to analyze the data. Achievement was measured by the Mathematics Concepts and Applications and Mathematics Computations subtests of the Comprehensive Test of Basic Skills.

TAI classes gained more than control classes on each test at each grade level. The differences were statistically significant for grades three and five on the Mathematics Computation subtest. On the Mathematics Concepts and Applications subtest, differences were statistically significant for grade four and marginally significant ($p < .09$) for grade five. In overall analyses, the TAI classes significantly exceeded control classes on both tests ($p < .001$).

Acknowledgment

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Adapting instruction to individual differences in ability or achievement has been one of the most persistent problems in American education for decades. At various times, opinions and practices have favored the use of tracking, within-class ability grouping, computer-assisted instruction, programmed instruction, and mastery learning as ways to help meet the need of each student for instruction at his or her own level. Particularly in mathematics, where learning each skill usually depends upon mastery of prerequisite skills, individualization of instruction has long been advocated.

However, at present, the educational pendulum has swung away from individualization. The ascendant direct instruction movement (e.g., Brophy, 1979; Good, 1979; Rosenshine, 1979) has generally included among its prescriptions for practice an avoidance of within-class ability grouping, programmed instruction, or other formal means of individualizing instruction. Proponents of direct instruction argue that individualization tends to require too much management time, depriving students of direct teaching time and forcing the assignment of large amounts of seatwork, which has been associated with low time on-task (e.g., Good and Grouws, 1977). Research on programmed instruction models, in which students work individually on their own learning packets at their own levels and rates, has found few advantages of these methods for mathematics achievement (e.g., Miller, 1976; Schoen, 1976).

However, the problem of accommodating student heterogeneity in mathematics instruction will not go away. If anything, such trends as mainstreaming, desegregation, shrinking school sizes, and abandoning of tracking are making classes more, not less, heterogeneous. Even if past solutions to this problem have failed to live up to expectations, the search for solutions to the problem of adapting instruction to different student needs must continue.

Recently a new method has been devised to teach mathematics in heterogeneous elementary school classes. This method, called Team-Assisted Individualization, or TAI, is a programmed instruction model designed to allow students with quite diverse mathematical skills to work at their own levels and rates. However, TAI also incorporates components drawn from a research tradition quite distinct from the programmed instruction tradition: Cooperative learning. In cooperative learning (Slavin, 1983) instructional methods, students work in small, heterogeneous learning groups and are rewarded based on the performance of the group members. Several dozen field experiments have established that these methods have positive effects on student achievement in a variety of subject areas, including mathematics, and have positive effects on such variables as ethnic relations, self-esteem, acceptance of mainstreamed students, and time-on-task (see Slavin, 1980, 1983).

TAI was designed to solve the perceived problems of programmed instruction by using cooperative learning teams composed of 4-5 students of all levels of past performance. In TAI, students work on programmed materials in their teams, and are rewarded based on the number of units completed by all team members and the accuracy of the final tests taken by all team members. Students themselves are responsible for almost all the management of the indivi-

dualized program, including checking of answers, filing of materials, assignment to new units, and so on. This frees the teacher to provide direct instruction to homogeneous teaching groups composed of students drawn from different teams.

The use of the cooperative teams in TAI is hypothesized to solve many of the problems of programmed instruction identified by critics (e.g., Kepler and Randall, 1977; Schoen, 1976). For example, critics have noted that these methods may reduce the teacher to the status of a program-checker, depriving students of direct instruction and extended explanations of mathematical concepts. In TAI, student management and checking of materials frees the teacher of this chore and allows the teacher to provide direct instruction.

Lack of motivation to proceed through materials accurately and at a rapid rate is another frequently mentioned problem of programmed instruction (e.g., Schoen, 1976). The team reward system in TAI is hypothesized to create within-team encouragement for academic efforts. Similar team reward systems have been consistently found to produce proacademic peer norms and to increase student achievement (see Slavin, 1983). Checking of materials by partners within the cooperative teams also provides students with immediate feedback on the correctness of their responses, enabling them to skip material on which they have shown mastery but spend adequate time on material with which they are having difficulty.

The TAI program has been evaluated in two recent studies reported by Slavin, Leavey, and Madden (in press). In both, students in the TAI classes gained significantly more in achievement than did control students. TAI students were also rated as better behaved by their teachers, and in one study,

TAI students were found to have more positive self-esteem in math and better attitudes toward math. Further, TAI students have been found to have more positive attitudes toward their mainstreamed, low-achieving classmates (Slavin, Madden, and Leavey, 1982).

However, the Slavin et al. (in press) studies were relatively brief. One study was in effect for eight weeks, and one for ten. The positive results might have been due to the novelty of the TAI program rather than to the particulars of the program itself. Also, the studies used only the Mathematics Computations subtest of the Comprehensive Test of Basic Skills (CTBS). It might be argued that the TAI program's positive effects on student achievement could have been due to a greater emphasis on computations than concepts relative to the control program.

The present study was conducted to investigate the achievement effects of the TAI program over a much longer period (24 weeks) and to use both the Mathematics Concepts and Applications and Mathematics Computations subscales of the CTBS to more fully assess achievement outcomes.

Method

Subjects and Design

The subjects were 1317 students in grades three-to-five in a suburban Maryland school district. Seven hundred students in 31 classes were assigned to use TAI, and 617 students in 30 classes matched on grade level, district-administered California Achievement Test (CAT) scores, and type of neighborhood were assigned to the control group. Analyses of covariance (ANCOVA), with CAT scores as covariates, were used to adjust CTBS posttest scores for

any remaining differences in pretest levels (none of which were statistically significant) and to increase statistical power.

Treatments

Team Assisted Individualization. The principal components of TAI were as follows:

1. Teams. Students were assigned to four- or five-member teams by the project staff. Each team consisted of a mix of high, average, and low achievers (as determined by a placement test), boys and girls, and students of any ethnic groups in the class represented in the proportion they made up of the entire class. Students identified as receiving resource help for a learning problem were evenly distributed among the teams. Students were reassigned to new teams every eight weeks by their teachers according to the same procedure.

2. Placement test. The students were pretested at the beginning of the project on mathematics operations. Students were placed at the appropriate points in the individualized program based on their performance on the diagnostic test.

3. Curriculum materials. During the individualized portion of the TAI process, students worked on prepared curriculum materials covering addition, subtraction, multiplication, division, numeration, decimals, fractions, word problems, and introduction to algebra. These materials had the following subparts:

--An Instruction Sheet explaining the skill to be mastered and giving a step-by-step method of solving problems.

--Several Skillsheets, each consisting of twenty problems. Each skillsheet introduced a subskill that led to final mastery of the entire skill.

--A Checkout, which consisted of two parallel sets of ten items.

--A Final Test.

--Answer Sheets for Skillsheets, Checkouts, and Final Tests.

4. Team Study Method. Following the placement test, students were given a starting point in the individualized mathematics units. They worked on their units in their teams, following these steps:

--Students formed into pairs or triads within their teams. Students located the units they were working on and brought them to the team area. Each unit consisted of the Instruction Sheet, Skillsheets, and Checkouts stapled together, and the Skillsheet Answer Sheets and Checkout Answer Sheets stapled together.

--Students exchanged Answer Sheets with partners within their teams.

--Each student read his or her Instruction Sheet, asking teammates or the teacher for help if necessary, and then began with the first Skillsheet in his or her unit.

--Each student worked the first four problems on his or her own Skillsheet and then had his or her partner check the answers against the Answer Sheet. If all four were correct, the student could immediately go on to the next Skillsheet. If any were wrong, the student had to try the next four problems, and so on until he or she got one block of four problems correct (asking teammates or the teacher for help if needed).

--When a student got four in a row correct on the last Skillsheet, he or she could take Checkout A, a ten-item quiz that resembled the last Skillsheet. On the Checkout, students worked alone until they were finished. When they were finished, a teammate scored the Checkout. If the student got eight or more items correct, the teammate signed the Checkout to indicate that the student was certified by the team to take the Final Test. If the student did not get eight correct, the teacher was called in to explain any problems the student was having. The teacher would then ask the student to work again on certain Skillsheet items. The student then took Checkout B, a second ten-item test comparable in content and difficulty to Checkout A. Otherwise, students skipped Checkout B and went straight to the Final Test. No student would take the Final Test until he or she had been passed by a teammate on a Checkout. When a student "checked out," he or she took the Checkout to a student monitor from a different team to get the appropriate Final Test. The student then completed the Final Test, and the monitor scored it. Two or three students served as monitors each day, rotating responsiblity among the class every day.

5. Team Scores and Team Recognition. At the end of each week, the teacher computed a team score. This score was based on the average number of units covered by each team member, with extra points for perfect or near-perfect papers. Criteria were established for team performance. A high criterion was set for a team to be a "SUPERTEAM," a moderate criterion was established for a team to be a "GREATTEAM," and a minimum criterion was set for a team to be a "GOODTEAM." The teams meeting the "SUPERTEAM" and "GREATTEAM" criteria received attractive certificates.

6. Teaching Groups. Each day, the teacher worked for 5-15 minutes with groups of students who were at about the same point in the curriculum. The purpose of these sessions was to prepare students for major concepts in upcoming units and to go over any points with which students were having trouble.

Control. The control group used traditional methods for teaching mathematics, which consisted in every case of traditional texts and group-paced instruction supplemented by small homogeneous teacher-directed math groups.

Mathematics Achievement Measures

The Mathematics Computations and Concepts and Applications subscales of the Comprehensive Test of Basic Skills (CTBS), Level 2, Form S, were administered as a posttest of student mathematics achievement for students in grades three and four. For fifth graders, Level H, Form U was used. The CTBS (rather than a curriculum-specific test) was used to be sure experimental and control classes would have equal opportunities to have their learning be registered on the test. No efforts were made to design the curriculum materials to correspond to the CTBS items. As noted earlier, California Achievement Test scores from routine district testing were used as covariates to control for initial differences in achievement. For third and fifth graders, the CAT scores were from the fall before the study began; for fourth graders, third-grade fall tests were used as covariates (as the district did not test fourth graders).

Results and Discussion

The data were analyzed by means of analyses of covariance. For analyses involving the CTBS Mathematics Computations Scale, CAT Mathematics Computations scores were used as the covariate; for CTBS Concepts and Applications, the corresponding CAT scores were used.

Analyses were conducted separately for each grade level. Also, an overall analysis was conducted by changing all scores to z-scores, adjusting posttest scores for covariates, and then conducting an analysis of variance on the residualized scores.

Table 1 About Here

The results are summarized in Table 1. All analyses were conducted using raw scores, but Table 1 presents grade equivalents for ease of interpretation of the different tests.

TAI classes gained more than control classes (controlling for CAT scores) on every test at every grade level. The differences reached statistical significance for Mathematics Computations at grades three and five, but not four. There were significant differences at grade four and marginal ($p < .09$) differences at grade five for Mathematics Concepts and Applications. In the overall analyses, the TAI classes significantly exceded control classes on both tests ($p < .001$).

These results support the conclusion of the Slavin, Leavey, and Madden (in press) studies that TAI is an effective program for accelerating mathematics

learning in elementary school. Differences were not statistically significant at every grade level for every test, but there were significant differences favoring TAI on one or the other test at every grade level, and the overall differences combined across grades were highly significant, averaging about a quarter of a grade equivalent.

These results make it unlikely that the positive effects of TAI on student achievement found by Slavin, Leavey, and Madden (in press) were artifacts of the novelty of the program, as novelty effects would not be expected to remain in effect for 24 weeks. Also, the fact that the effects of TAI were as strong on Concepts and Applications as on Computations is an indication that the program not only benefits basic skills, but also affects higher-order mathematical learning.

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Table 1
Experimental Results in Grade Equivalents

	TAI	Control	F	p <
Grade 3-Comp.				
Pre (Gr. 3 CAT)	3.85	3.69		
Post (CTBS II)	4.88	4.61	5.81	.02
N	246	204		
Grade 3-C & A				
Pre	4.48	4.35		
Post	5.35	5.06	1.86	NS
N	245	206		
Grade 4-Comp				
Pre (Gr. 3CAT)	3.71	3.39		
Post (CTBS II)	5.71	5.37	<1	NS
N	219	162		
Grade 4-C & A				
Pre	4.16	4.00		
Post	6.63	5.97	10.80	.001
N	217	164		
Grade 5-Comp.				
Pre (Gr. 3 CAT)	6.15	6.26		
Post (CTBS H)	7.49	7.27	19.61	.001
N	239	247		
Grade 5-C & A				
Pre	6.88	6.68		
Post	8.02	7.65	2.86	.09
N	238	247		
Overall-Comp				
Pre	4.59	4.65		
Post	6.02	5.88	13.12	.001
N	704	613		
Overall-C & A				
Pre	5.20	5.19		
Post	6.49	6.34	13.61	.001
N	700	617		